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ABSTRACT

Public policy with respect to industrial arts as a part of general education is almost nonexistent. In fact, one finds little true commitment to the field except by its practitioners, and they frequently report such problems as not having a textbook available for their course or having school counselors assign to their courses students who cannot read. This situation is especially critical when considered in light of the competition that the United States is currently facing in such areas as heavy industry, manufacturing, and microprocessor and information technology. At long last, others concerned with the need for technological literacy have realized that the industrial arts/technology education field has a vital role to play in revitalizing the Nation's economy by increasing the understanding of technology among its citizens. One way to enable industrial arts to accomplish this mission would be to create a national center for the study of technology and human affairs that could provide the level of academic and political leadership required for the development and implementation of appropriate public policy concerning technology education. (MN)

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Education--Technology
and
Public Policy

Public policy with respect to industrial arts as a part of general education is almost non-existent. In fact, one finds little true commitment to the field except by the practitioners of the field and they find they are fighting a losing battle in trying to persuade others in education that their field of study is important. It seems the practitioners of industrial arts education are always waging a status battle. There are many reasons why this is so, from the failure to develop programs of instruction compatible with an espoused philosophy, to being confused about the central mission of the field.

The present structure has vestiges of trade and job analysis, occupational training, manual training and crafts. C. Daniel Miller, State Specialist for Industrial Arts in Alabama, has described the problem very accurately in the March 1983 issue of the ACIATE Newsletter. Miller notes: "As a state specialist for industrial arts I would be ecstatic if the programs I typically encounter were teaching the arts of industry. The only industry I see emulated is the village handiman and carpenter, or the local furniture maker at best... High technology here is a new carbide-tipped saw blade."

An evaluation of teacher education program specialities by faculty in various faculty directories illustrates where part of Miller's problem begins. You will find a very diverse set of descriptors

ranging from woods, metals, drawing, manufacturing, industrial safety, industrial hygiene, power, energy, printing, building construction, graphic arts, electronics, quality control and plastics to auto body/auto restoring.

Unless there is a close relationship between philosophy and practice these rather strange curricular structures will continued. The written or unwritten philosophical position concerning industrial arts purpose and mission dictates the choices made. In an investigation by DeVore, Griscom and Maughan ( ) they found four classifications of content and instruction; occupations, products, systems and skills, none of which are mutually exclusive.

John Feirer, Executive Editor of Industrial Education, in his March 1983 editorial titled "What Student Teachers Tell Us" reported some rather startling facts which affect the status, importance and quality of industrial arts programs. Feirer reports that about one third of the student teachers stated that there was no course of study for the class to which they were assigned. Most critic teachers operated "off the cuff."

Over one half of the student teachers reported that no textbook was available in the classes in which they were participating. More than half of the student teachers were never asked to give a demonstration. These same student teachers reported that school counselors still assign students to industrial arts courses in auto mechanics or electronics even though they cannot read. Many students assigned to their classes have physical and emotional problems which affect their ability to perform in an industrial arts laboratory.

Many industrial arts teachers are no longer involved in the study of industry or technology. Their programs have been altered to serve special needs students. Knowing the nature of many industrial arts programs in the public school this may be a worthwhile direction. Why? Because, finally, there is a specific justifiable role for industrial arts in the public school: take care of those who are discipline problems, handicapped and intellectually incompetent.

One wonders how we reached this state, given our rather noble mission. Is it because the vigorous programs of the past have stagnated as Everett N. Israel suggested in his two part article in the January and February 1981 issues of Man/Society/Technology? Israel calls for establishing a new sense of direction. Is this possible except as an esoteric exercise when so many of the factors affecting industrial arts result from the establishment and operation of public policies in which the profession has had no role?

Many times over the last several decades members of the profession have tried to set new directions, the latest published effort being the Jackson's Mill Industrial Arts Curriculum Project. To date there does not seem to be a movement by public schools or teacher education programs to adopt the proposed curriculum structure.

During the 1960s and '70s there were over twenty widely publicized curriculum efforts. And what has been the result? One need only review the findings of the Standards for Industrial Arts Project conducted by William Dugger and his staff at Virginia Polytechnic Institute and State University to find that the curriculum projects of the 1960s and '70s had little or no effect.

But there are effects. The effects are coming from abandoned public school and teacher education programs, from teachers opting for early retirement rather than continue the hassle and from a growing awareness by those still in the profession of the great discrepancy between the real world and the industrial arts world.

The Real World

We are no longer an isolated nation. We no longer are in control of our destiny. We live in an interdependent changing world, a world of accelerating industrialization, rapid population growth, widespread malnutrition, increasing depletion of non-renewable sources of minerals and energy and a deteriorating environment.

On a local scale we find that many of our neighbors are unemployed and perhaps will never return to their place of work. Those who are employed have discovered that because of inflation and a recession that even though they are well educated and a part of the middle class they cannot maintain a life style that only a few years ago was considered normal.

We find that the United States is no longer competitive in heavy industries, and faces heavy competition from other nations in computer technology, machine tools, construction equipment, automobiles, electronics and home appliances.

In less than eighty years the United States has changed from an agricultural to an industrial to a service economy. Manufacturing, mining and construction combined account for only 35 percent of the jobs. It is predicted by various sources that by 1990 the service

sector--banking, insurance, the communication and information industries and fast food restaurants will provide 80 percent of the jobs. Many jobs in these fields are low in pay and offer few career advancement opportunities.

The heavy industries--steel, auto, and machine tools--will be replaced in the economy by businesses and industries that facilitate, move, service, and manage rather than make things. Manufacturing and heavy industry have been and are moving to other countries where the wages are lower and the most sophisticated equipment and management techniques are employed. The new era is focused on electronic computing equipment, telecommunications, instrumentation and control devices using semiconductors, the health fields, entertainment equipment and space vehicles and satellites. Some of the new communication firms are already recording market values twice those of large steel and aluminum producers.

These changes have been brought about by human endeavors in creating and using technical means. Major changes in society have always come about when human potential was altered through developments in the technical means which provided:

1. A more stable food supply
2. New and better materials
3. Alternative forms of energy supply
4. A more efficient means of energy conversion
5. A more efficient means to:
   (a) collect
   (b) store
   (c) transmit and
   (d) process information and
6. A better means to <u>control</u> tools, machines and technical systems.

The latter two factors concerning information and control are of major importance today and are the variables that are altering societies throughout the world. Most people are acquainted with the elements that have brought about the communication and information revolutions of today. These include the telephone, telegraph, phonograph, radio, photography, motion pictures and television.

The two major breakthroughs, however, and the developments which form the core of the information-systems revolution of the last quarter of the twentieth century, were the creation of programmable electronic computers and the invention of the transistor in the late 1940s. The computer provided the capability to manipulate and transform information; the transistor, the potential for small and reliable sensing and control devices so essential to the high-speed automatic collection and processing of information.

The fusing of computer technology and communication technology gave birth to information-systems technology, a new technology which has altered and will continue to alter the very existence of humankind.

The Information Revolution

In the 1950s there were some 1000 or so computers, but no microcomputers or microprocessors. In the late 1970s there were over 220,000 computers and some 750,000 microprocessors. During the 1980s the number of microprocessors will exceed 10 million and usher in a new technological revolution that, from all predictions, will have a greater and more profound impact on societies throughout the world than did the industrial revolution.

All aspects of living are being affected directly or indirectly; education, the home, agriculture, transportation, recreation and medicine. New uses and applications are being developed every day. Microprocessors provide the means for control of all forms of industrial and business operations providing what has been called intelligent automation. Microprocessors are used in oil refineries, chemical plants, paper mills, steel mills, power stations, research laboratories, offices, and homes. They are being used to control internal combustion engines to improve fuel economy and lessen pollution. The range of applications is staggering.

The development of the microprocessor came about in 1969 when an engineer for Intel Corporation, M. E. Hoff, was searching for a better way to produce silicon chips for use in electronic calculators. He found it was possible to incorporate the entire central processing unit (CPU) of a computer onto a single silicon chip. Combining the microprocessor with additional chips to provide other functions such as memory, Hoff created a micro-sized computer. By 1980, his creation had evolved to where a pocket computer selling for less than $250 had computational powers comparable to ENIAC (the first electronic computer) and considerably more memory. ENIAC had 18,000 vacuum tubes, occupied a large sized laboratory room and weighed over one ton, and was far less reliable.

Another critical turning point, which enabled the large scale application of microprocessors, was the development of the means to manufacture a silicon chip with tens of thousands of electronic components and complex circuits imprinted on it.

Silicon chips are about one-fourth the size of a standard postage stamp. This breakthrough reduced the size of electronic equipment and increased the power and flexibility of small computers, while at the same time costs were reduced on the order of 100,000-fold.

The construction and design of integrated circuits, the core of microelectronics, have improved so that greater numbers of transistors, resistors, diodes and other electronic components can be placed on a single silicon chip. In 1971, Intel, Inc., following the work of their engineer, M. E. Hoff, brought out the microprocessor by putting the entire central processing unit of a computer on a chip. By 1980, the power and the capability of the microprocessor were increased by new manufacturing capability enabling the placement of 200,000 components on a single chip. The Japanese have chips in development that will contain 250,000 circuits. By 1985, manufacturers predict integrated circuits will be available with one million components and by 1990 as many as 10 million transistors on a single chip.

The microprocessor has brought about the potential of robotics and a continuing change in the nature and distribution of jobs. It is evident that most people in the world are entering a new world for which they are not very well prepared whether the question concerns their knowledge of and ability to perform in the new technologies or their understanding of the primary questions of all time: Who are we?, Why are we here?, Where are we going?, How will we get there?

The New Mission for Industrial Arts

These are the questions many in the industrial arts profession are asking today. Interestingly, after many years of virtually standing alone, the industrial arts profession has company. Others have been awakening to the fact that we are not very literate about the creation and use of technical means--tools, machines, materials, techniques and technical systems and the relation of the behavior of these elements and systems to human beings, society and the civilization process. Others have become aware of the importance of technology in human affairs and how ignorant we are of this relationship.

The Council for Understanding Technology in Human Affairs, the National Academies of Science and Engineering and the American Association for the Advancement of Science have sponsored meetings on the issue of technological literacy. The National Science Foundation has appointed a commission to develop plans for improvements in the teaching of science and technology in the public schools. The Alfred P. Sloan Foundation recently awarded $250,000 each to ten liberal arts colleges for the purpose of developing curricula to increase the technological literacy of liberal arts graduates.

Business and industry are heavily involved also. They are investing some $3 billion yearly to fill what they consider is an education gap between what people are learning in education institutions and what they need to be competent employees.

The proposed new mission for professionals in the industrial arts/technology education field of increasing the understanding of

technology among all people focuses on a purpose that is vital to our country and to each and every individual.

The Study of Technology

We consider the study of biology, sociology and psychology as well as other fields of study to be essential for the attainment of literacy about life, self and society. But for some reason, the study of technology is omitted even though the most casual observer can determine that endeavors by humans in creating technical means have brought about an evolution of the human species not possible through biology.

The very survival of the human species and the evolution of society have depended not on the accessibility of resources or favorable climates but on the creation and use of tools, techniques and technical systems. Phillip Bock, the anthropologist, reminds us of the importance of tools in our society.

> If the world were arranged entirely for our convenience we should have no use for tools, but it is not. Matter and energy are seldom found in exactly the right forms or quantities to satisfy our needs. The sun rises and sets without regard to our desire for light or heat. Food and water do not appear whenever we are hungry or thirsty. And various obstacles come between us and the objects of our desires.

If we are to remain as free citizens in a democratic society and control our own destiny, then it is important that we control our technical means and direct and use them to attain agreed upon social purposes. To do otherwise will bring about a society controlled by an elite group who are knowledgable in creating and controlling technical means for their purposes.

A technological society is a knowledge society and requires new forms of literacy for all citizens to function effectively as free and responsible members of the society. It is critical in a democratic society that all members understand the multiple relations among various technical systems and human affairs.

Technological Literacy

The tradition of education has been to separate the liberal education from technological education. Today, educators from all segments of the spectrum are embracing the study of technology as a part of basic education and the new liberal arts. A new form of literacy is being called for, a technological literacy. What does it mean to be technologically literate?

If the question was, "What does it mean to be literate in French or Russian?", the reply would be that the student should be able to speak, read and write in the French or Russian language, implying a knowledge and understanding of the words, symbols, syntax and structure of the language as well as the ability to perform using the language. It also implies a knowledge and understanding of the history and culture of the countries where

the language is primary. Similar criteria apply with respect to technological literacy.

Today, we live in a complex, interrelated, computerized technical society. The first requirement of a technological society is that it is an educated society, an enlightened and informed society. The best way to focus on the centrality of this rather obvious point is to remember that each and every person on earth is a member of the spaceship earth. The more sophisticated the spaceship and the more crew members, the greater the task of educating people to manage and control it for the safety and security of all.

It would seem that each crew member must have a level of literacy about the functioning of our complex ship so that they will be able to make informed decisions and will not become frustrated by its technical nature so that they fear it and become alienated by it. This requires citizens knowledgable about the characteristics, capabilities and limitations of the technological environment of the spaceship and the impact of their choices about the technical design of the spaceship on their future and the future of unborn generations.

The creation and use of technical means is a large and complex area of human intellectual activity which has evolved over the centuries and has had great social and psychological impact, but is little understood by society. And as critical as the understanding of technical systems is, as a basis for determining public policy and the management and control of technological systems, little effort has been made by public education to address the issue of technological literacy.

A large portion of our population live in total ignorance about technical systems; their creation, evolution, capabilities, operations and limitations. Most live with perpetuated myths and folk knowledge that detract from true understanding. However, many people are becoming aware of the significance of the problems. For instance, concern has been increasing about the issue of technological literacy. It has become a critical issue because of the problems of society resulting from what is called an industrialized or corporate technical society.

Institutionalized or public education has always focused on literacy and training for the corporate or industrial need. These training programs are called vocational, occupational and career education. The education system has become linked more closely to the needs of business and industry through these programs. The type of literacy required by this approach to literacy is job specific, less complex and seldom transferrable to new and evolving technical systems, a fact that is proven each time jobs are eliminated by technological change or obsolescence as in the steel industry.

The other form of technological literacy focuses on the role of the individual in a free society as a citizen of a community, state, nation and world who functions in many roles and is responsible for the proper functioning of the spaceship today and for the long-term sustainable future. This is a much more complex level of technological literacy than the literacy required to obtain and sustain a job in a corporate enterprise.

There are many ways of structuring a program of technological literacy. An economist would focus on the production function, an

engineer on the technical, an anthropologist on the cultural and a sociologist on the social. None of these approaches is sufficient to structure a program of technological literacy today. What is needed is the focus of the technologist who is concerned with the study of the creation and use of technical means--tools, machines, techniques, technical systems--and the behavior of technological systems in relation to people, their societies, the environment and the civilization process. The technological literacy of today and tomorrow must be based on a unifying, integrating study of the behavior of natural, technical and social systems and their interrelationships.

This requires a new knowledge base incorporating the study of humankind, other cultures; technical and social systems and the behavior of these systems; processes of decision making; change processes; the history of technical means; goals and values in human societies; technological assessment; the interrelation of systems and the behavior and control of systems, both technical and social; the invention and innovation process and new technologies and technological systems including energy systems, transportation systems, communication systems and production systems; alternative and future social and technological systems; and the process for designing new technologies and new social and technical skills, among others.

The new literacy must also incorporate the concepts, relationships, and consequences of technical means, together with knowledge and know-how in the appropriate selection and design of technical means and the process of transfer and adoption of new means into society with the least impact on people, the social system or the environment.

Thus, the focus o the new literacy is on the process of creating, using and assessing technical means at several levels. These levels range from a knowledge of the function and use of tools in the broadest sense of the term, to the design of products produced by people using tools, and the use, relation and impact of the products on people, society and/or the environment.

Most efforts concerned with technological literacy have focused on knowing about and using tools or on assessing the impact or effects of technical means. Both are restricted efforts and fail to attain a true literacy. All too often it has been assumed that a casual encounter with tools or the reading of a book or two on technological and social change will produce a technologically literate person. This surface treatment fails to comprehend the complexity and interrelatedness of the task. True literacy will require a sustained effort over time to develop knowledge and understanding of the abstract concepts upon which the technical world has been created and functions. This level of understanding cannot be gained from hearing or reading about inventions and technical systems. What is required is direct and sustained involvement in the processes of the technologist. The mind must be prepared to be capable of observing and establishing differences, similarities and relationships. Human beings are not only perceptual beings, they are also conceptual. They are capable of learning and using technological modes of thought. Harold Halfin, in his study of the intellectual processes or methods of inquiry used by technologists, identified seven distinct processes. The processes are defined as "those functional or intellectual skills which are the random or

ordered methods, strategies, or operations used by a technologist to accumulate knowledge about an artifact or to solve a technological problem" (Halfin).

1. Defining the problem or opportunity operationally
2. Observing
3. Analyzing
4. Visualizing
5. Computing
6. Communicating
7. Measuring
8. Predicting
9. Questioning and hypothesizing
10. Interpreting data
11. Constructing models and prototypes
12. Experimenting
13. Testing
14. Designing
15. Modeling
16. Creating
17. Managing (p. 207)

A significant part of the literacy issue is language. Language is not just a means of communicating thoughts, ideas, concepts or technical information; it also structures the way people perceive themselves and how they act and function. Being technologically literate requires that the individual be conversant in several technical languages including the symbolic languages of the various systems.

Finally, to be technologically literate requires a knowledge and understanding of systems.

Technological Systems

Technological systems are composed of elements that are related and which interact in some way. Everything exists in relation to other elements within an immediate and total environment. This means that there is some context within which an element, particle, person, tool, event, action or some other part of a system, acts and is acted upon. Perceiving the dynamics of a system requires the identification of some central theme, function or behavior, whether the concern is with the composition and behavior of a given material or of an electronic communication system.

First steps in comprehending a system often involve classification, either at the micro or macro levels. Classifying is the process of ordering and organizing that which is observed about component elements or parts. By classifying or ordering the elements of an on-going dynamic event, a beginning is made in the understanding of the behavior of the element in relation to other elements.

There are different types of classification systems designed for different purposes. Some merely group like objects or elements, as is done in the Dewey decimal or Library of Congress systems for classifying books, the Department of Commerce system for classifying industries, or the Department of Labor system for classifying occupations. These might be referred to as static systems.

Taxonomic analysis is another way to classify the component elements of a system. A taxonomy orders elements according to a central theme, a hierarchy, and relationships.

Certain universal technological endeavors exist in all societies at some level of sophistication. They include the means of producing artifacts, transporting goods and services, and transmitting information. Each of these systems can be classified and analyzed as subsystems according to function, activity, or problem category. Examples include categories such as manufacturing, constructing and processing; terrestrial, marine, air and space transportation systems; and systems of information transmission, storage, retrieval and use. To be technologically literate, a knowledge and understanding of the evolution, structure and behavior of these systems is essential, together with experience in designing, constructing, using and assessing technical devices associated with various technological endeavors in the several systems.

Leadership in Public Policy

The task of the industrial arts profession, if its mission is to be technological literacy, will be long and arduous. Even though the profession claims to be involved in the study of industry and technology, nothing could be further from the truth in most public school and teacher education programs. In most cases nothing short of a complete restructuring will be required.

The problem is one of change; change of the practitioners, administrators, public attitude, curricula, instructional processes and facilities, among others.

The usual way the profession has called for change is to make a pronouncement, create a few publications and then stand back and criticize the classroom teacher because nothing happened. It seems as if there are no answers, at least individually and locally. But what if we pursued the problem collectively and nationally? What if we initiated an effort to create a national Center for the study of technology and human affairs; a Center where the problems would be researched; where teacher educators could be retrained and certified; where standards for programs could be developed, where pilot programs could be designed and tested; where citizens and educators could meet with researchers and practitioners to plan for the future, where program standards would be developed and where appropriate and accurate information about education in the technologies would be distributed on a national basis?

The financing, structuring, organizing and operating of such a Center will be formidable tasks, but ones that can be accomplished.

The profession needs a means to move beyond its present stagnated status. Our youth and our nation need long term leadership for technology education. The task will never be done. The technical base of society will continue to evolve. A National Center for the Study of Technology and Human Affairs could provide the level of academic and political leadership required for the development and implementation of appropriate public policy concerning technology education.

The education of our youth about the evolving technological culture is one of the most important missions in education today. What is needed is the means to carry out the mission at all levels of education in all communities throughout the nation. I propose that a prestigious, quality National Center is the means to aid us, not only at this time of need but in the future, by providing the means to remain on the forefront in what will always be a changing content and problem base.